Recent progress in B physics

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We firstly address the recent efforts on calculations of the next-to-leading order corrections to the color-suppressed tree amplitude in QCD factorization method which may be essential to solve the puzzles in $B \to \pi\pi$ and πK decays. Then we discuss the polarization puzzles in $B \to \phi K^*$ and ρK^*. The impacts of the newly measured $B_s - \bar{B}_s$ mixing and $B^+ \to \tau^+\nu$ on the CKM unitarity triangle global fitting are mentioned. We also briefly review the recent measurements of the new resonances at BaBar and Belle. Finally, some new results from hadron colliders, especially the b-flavored hadron spectra, are discussed.

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INTRODUCTION

The study of B meson decays plays an important role in determining the CP-violating parameters in the Standard Model (SM) and discovering new physics in the flavor-changing processes. In particular, B non-leptonic two-body decays provide an abundant sources of information about the CKM matrix. For example, the most promising measurement of $\sin 2\beta$ (α,β and γ are three angles in the unitarity tri-angle) is from measurement of the time-dependent CP-asymmetry in $B^0 \to J/\Psi K_S$. $B \to \pi\pi$, $\rho\pi$ and $\rho\rho$ are also very important for determining $\sin 2\alpha$. However, the theoretical calculation of these hadronic decays suffers from the complicated strong interactions which compromise the precision of the determination of the CKM matrix elements from the experimental data. Thus the higher order calculation of such decays are essential for a better understanding of the CP violations.

Besides the non-leptonic decays, the new measurements on $B_s - \bar{B}_s$ mixing and $B^+ \to \tau^+\nu$ have a great impact on constraining the unitarity tri-angle. Both of two decay modes are also sensitive to new physics.

The B decays also offer us a good place to study the strong interaction dynamics in heavy flavor systems. In the abundant decay products of B mesons, experimentalists observed a lot of new hadron resonances at BaBar and Belle. They are mainly excited (or exotic) charmed mesons and charmonium states.

The excited B-mesons and b-baryons can be only studied at the hadron colliders. We will briefly review the spectrum of the excited B mesons and b-flavored baryons from the measurements at TEVATRON.

$B \to \pi\pi$ AND πK PUZZLES

$B \to \pi\pi$ and πK are the most popularly studied two-body decay modes in B physics in addition to $B \to J/\Psi K_S$. The big experimental achievement is that the direct CP asymmetries in these decays have been observed. The latest world averages are[1]

$$\begin{aligned} A_{CP}(\pi^+\pi^-)|_{\text{exp.}} &= 0.38 \pm 0.07, \\ A_{CP}(\pi^+K^-)|_{\text{exp.}} &= -0.095 \pm 0.013, \end{aligned} \tag{1}$$

both of which are 5σ away from zero.

$B \to \pi\pi$ are dominated by tree amplitudes. Due to the isospin symmetry, the decay amplitudes of tree $B \to \pi\pi$ modes can be parameterized graphically as the following

$$\begin{aligned} \mathcal{A}(\pi^+\pi^-) &= Te^{-i\gamma} + P, \\ \sqrt{2}\mathcal{A}(\pi^0\pi^-) &= (T + C)e^{-i\gamma}, \\ \mathcal{A}(\pi^0\pi^0) &= -Ce^{-i\gamma} + P, \end{aligned} \tag{2}$$

where T, C and P stand for the color-allowed, color-suppressed tree amplitude and penguin amplitude respectively. According to the naive factorization, the ratios $|C/T|$ and $|P/T|$ are expected to be small. This leads to that the $\mathrm{Br}(\pi^0\pi^-)$ is almost half of $\mathrm{Br}(\pi^+\pi^-)$, and $\mathrm{Br}(\pi^0\pi^0)$ is very small. However, this expectation is strongly against the experimental data[1]

$$\begin{aligned} 10^6\,\mathrm{Br}(\pi^+\pi^-)_{\text{exp.}} &= 5.16 \pm 0.22, \\ 10^6\,\mathrm{Br}(\pi^0\pi^-)_{\text{exp.}} &= 5.7 \pm 0.4, \\ 10^6\,\mathrm{Br}(\pi^0\pi^0)_{\text{exp.}} &= 1.31 \pm 0.21, \end{aligned} \tag{3}$$

which requires $|C/T| \simeq 0.7$. It means that the color-suppression is not valid any more.

For $B \to \pi K$ decays, the similar graphical parameterization can be written as

$$\begin{aligned} A(\pi^-\bar{K}^0) &= P', \\ \sqrt{2}A(\pi^0K^-) &= [P' + P^{EW}] + e^{-i\gamma}[T' + C'], \\ A(\pi^+K^-) &= P' + e^{-i\gamma}T', \\ -\sqrt{2}A(\pi^0\bar{K}^0) &= [P' - P^{EW}] - e^{-i\gamma}C', \end{aligned} \tag{4}$$

in which penguin amplitude P' dominates comparing with the color-allowed tree amplitude T', color-suppressed tree amplitude C' and the electro-weak penguin P^{EW}. $A_{CP}(\pi^+K^-) \simeq A_{CP}(\pi^0K^-)$ is expected if

$\mathrm{Br}\times 10^6$	G_4	Exp.	A_{CP}	G_4	Exp.
$\pi^0\pi^-$	5.6	5.7 ± 0.4	$\pi^0\pi^-$	0.00	0.04 ± 0.05
$\pi^+\pi^-$	5.7	5.16 ± 0.22	$\pi^+\pi^-$	0.04	0.38 ± 0.07
$\pi^0\pi^0$	0.81	1.31 ± 0.21	$\pi^0\pi^0$	-0.38	0.36 ± 0.33
$\pi^-\bar{K}^0$	22.6	23.1 ± 1.0	$\pi^-\bar{K}^0$	0.00	0.008 ± 0.0025
π^0K^-	12.9	12.8 ± 0.6	π^0K^-	-0.05	0.047 ± 0.026
π^+K^-	20.6	19.4 ± 0.6	π^+K^-	-0.02	-0.095 ± 0.013
$\pi^0\bar{K}^0$	9.1	10.0 ± 0.6	$\pi^0\bar{K}^0$	0.04	-0.12 ± 0.11

TABLE I: Predictions in QCDF with NLO HSI vs. experimental data.

$|C'/T'|$ and $|P^{EW}/P'|$ are small. However, the recent experimental data shows $A_{CP}(\pi^0K^-)=0.047\pm 0.026$. It requires either the enhancement in P^{EW} or C'. The large P^{EW} scenario [3] seems to be going away with the new experimental measurement of $\mathrm{BR}(\pi K)$. $|C'/T'|\simeq 1.1$ is needed to meet the data. So similar to the situation in $B\to\pi\pi$, the color-suppression for $C^{(\prime)}$ is not valid any more.

In QCD factorization, these color-suppressed amplitudes are related to the QCD coefficient $\alpha_2(M_1M_2)$. For illustration[2],

$$\alpha_2(\pi\pi) \;=\; 0.17_{rmLO}-[0.17+0.08i\,]_{V_2} + \begin{cases} [0.18]_{\mathrm{LOHSI}} & \text{(default)} \\ [0.46]_{\mathrm{LOHSI}} & \text{(S4)} \end{cases} \tag{5}$$

The accidental cancellation between the leading order (LO) and next-to-leading order (NLO) vertex corrections (V_2) makes the hard spectator interaction (HSI) very important. The NLO corrections to the HSI are recently studied by Beneke, Jager and Yang[4, 5, 6]. In their papers, the corrections from the two scale regions are encoded into the jet function and hard coefficient respectively, both of which enhance the color-suppressed amplitude effectively.

In Table I, the predictions in QCDF with NLO HSI in a certain parameter setting (G_4) is shown. The agreement between the prediction and experimental data is very good except for the direct CP asymmetries A_{CP}. It means that the strong phases still need further study. Recently, the efforts towards the NLO corrections to the imaginary part of the amplitude has started. In [7], the next-next-to-leading order vertex corrections has been considered.

$B\to VV$ AND POLARIZATION PUZZLES

B decays to two light vector mesons offers more abundant observables than $B\to PP$ and PV since the final vectors can be polarized both longitudinally and transversely. The fact of the $V-A$ dominance in the Standard Model (SM) shows the hierarchy of the helicity amplitudes for $B\to VV$

$$A_0:A_-:A_+ = 1:\frac{\Lambda}{m_b}:\left(\frac{\Lambda}{m_b}\right)^2 \tag{6}$$

with simple estimation by the naive factorization. This argument leads to the expectation that $B\to VV$ is dominated by longitudinal polarization. However, experimentally, such hierarchy is obeyed in the tree-dominated decays ($B\to\rho\rho$ and $\omega\rho$), but violated in penguin dominated $B\to\phi K^*$ system[8]. This attracts a lot attentions from the theorists. Many solutions are offered on the table, such as new physics (scalar or tensor coupling), final state interaction, charming penguin, the form-factor tuning, large penguin annihilation etc[9].

The more puzzling case happens in $B\to\rho K^*$ system which are penguin-dominated, in which both transverse polarization is enhanced in $B^-\to\rho^-\bar{K}^{*0}$ but suppressed in $\bar{B}^-\to\rho^0K^{*-}$[10].

Analogue to $B\to PP$ and PV, QCD factorization formula for $B\to VV$ reads[11]

$$\langle V_{1,h}V_{2,h}|Q_i|\bar{B}\rangle = F^{B\to V_{1,h}}\,T_i^{I,h} * f_{V_2}^h\Phi_{V_2}^h + \; T_i^{II,h} * f_B\Phi_B * f_{V_1}\Phi_{V_1} * f_{V_2}^h\Phi_{V_2}^h + \mathcal{O}(1/m_b)\,. \tag{7}$$

Also similar to $B\to PP$ and PV, the annihilation contribution brings the large uncertainties to the QCD factorization prediction in $B\to VV$ as well due to the severe endpoint singularity. However, the penguin weak annihilation in longitudinal helicity amplitude is predicted to be small and with small uncertainty, perhaps due to an accidental cancellation; in negative-helicity amplitude, the penguin weak annihilation could be very large. This leads to two consequences:

1) For the tree-dominated decays which are dominated by the longitudinal polarization, the penguin amplitude gives small contribution to the branching ratios. As a result, we could have a better determination of $\sin 2\alpha$ or α from $B\to\rho\rho$ than $B\to\pi\pi$ and $\pi\rho$.

2) For the penguin dominated decays, the negative-helicity amplitude could be (need not to be) large. This can be an solution for the $B\to\phi K^*$ polarization puzzle. However, in this case, QCD factorization loses its predictive power.

The decay amplitudes for $B\to\rho K^*$ system could be parameterized graphically as Eq.(4) except for each amplitude replaced by the one noted by helicity. To explain the polarization fraction in $B\to\rho K^*$ system, we need large electroweak penguin for negative-helicity amplitude. Such enhancement can be obtained if consider the electromagnetic dipole operator in the effective weak Hamiltonian

$$\mathcal{H}_{\mathrm{eff}} \;=\; \frac{G_F}{\sqrt{2}}\sum_{p=u,c}\lambda_p^{(D)}\sum_{a=-,+}C_{7\gamma}^aQ_{7\gamma}^a+\ldots, \tag{8}$$

$$Q_{7\gamma}^{\mp} \;=\; -\frac{e\bar{m}_b}{8\pi^2}\,\bar{D}\sigma_{\mu\nu}(1\pm\gamma_5)F^{\mu\nu}b, \tag{9}$$

FIG. 1: Leading contributions to $\Delta\alpha^{p\mp}_{3,\mathrm{EW}}(V_1V_2)$ defined in the text.

$B^- \to K^{*-}\rho^0$	with ΔP^{EW}	without ΔP^{EW}	experiment
BrAv$/10^{-6}$	4.5	5.4	< 6.1
f_L / %	84	70	96^{+6}_{-16}

TABLE II: The enhanced electroweak penguin in $B \to VV$.

where $\lambda_p^{(D)} = V_{pb}V_{pD}^*$. This effect is neglected in any calculation of $B \to VV$ before [12]. In Figure 1, the small virtuality of the photon can not be cancelled when the final vector V_2 is transversely polarized. This results in the enhancement of the electorweak penguin in negative-helicity amplitude

$$\Delta P^{\mathrm{EW}}(V_1V_2) \propto -\frac{2\alpha_{\mathrm{em}}}{3\pi}\, C^-_{7\gamma,\mathrm{eff}} \frac{m_B \bar{m}_b}{m^2_{V_2}}. \quad (10)$$

In Table II, we can see this effect obviously where the penguin amplitudes are extracted from the experimental data.

In Table III, the predictions for $B \to \phi K^*$ and ρK^* by QCD factorization are listed. ("$\hat{\alpha}_4^{c-}$ from data" means the penguin of negative-helicity amplitude is extracted from the experiments.) One can see that the predictions agree with the experimental data very well. It reproduces the polarization pattern of the penguin-dominated $B \to VV$ decays as well.

Observable		Theory		Experiment
		default	$\hat{\alpha}_4^{c-}$ from data	
BrAv$/10^{-6}$	ϕK^{*-}	$10.1^{+0.5+12.2}_{-0.5-7.1}$	$10.4^{+0.5+5.2}_{-0.5-3.9}$	9.7 ± 1.5
	$\phi \bar{K}^{*0}$	$9.3^{+0.5+11.4}_{-0.5-6.5}$	$9.6^{+0.5+4.7}_{-0.5-3.6}$	9.5 ± 0.8
	$\bar{K}^{*0}\rho^-$	$5.9^{+0.3+6.9}_{-0.3-3.7}$	$5.8^{+0.3+3.1}_{-0.3-1.9}$	9.2 ± 1.5
	$K^{*-}\rho^0$	$4.5^{+1.5+3.0}_{-1.3-1.4}$	$4.5^{+1.5+1.8}_{-1.3-1.0}$	< 6.1
$f_L/\%$	ϕK^{*-}	45^{+0+58}_{-0-36}	44^{+0+23}_{-0-23}	50 ± 7
	$\phi \bar{K}^{*0}$	44^{+0+59}_{-0-36}	43^{+0+23}_{-0-23}	49 ± 3
	$\bar{K}^{*0}\rho^-$	56^{+0+48}_{-0-30}	57^{+0+21}_{-0-18}	48.0 ± 8.0
	$K^{*-}\rho^0$	84^{+2+16}_{-3-25}	85^{+2+9}_{-3-11}	96^{+6}_{-16}

TABLE III: QCD factorization predictions for $B \to \phi K^*$ and ρK^* vs. experimental data.

$B_s - \bar{B}_s$ MIXING AND $B^+ \to \tau^+\nu$

CDF and D0 have measured the $B_s - \bar{B}_s$ oscillation frequency [13]. We get the average of

$$\Delta m_s = (17.77 \pm 0.10 \pm 0.09)\mathrm{ps}^{-1}$$

Comparing with $B_d - \bar{B}_d$ mixing[1]

$$\Delta m_d = (0.507 \pm 0.004)\mathrm{ps}^{-1},$$

we can set the bound for

$$|V_{td}/V_{ts}| = 0.206 \pm 0.008.$$

Consequently,

$$\gamma = (66 \pm 6)^\circ.$$

Belle has declared the evidence for purely leptonic decays $B^- \to \tau^-\bar{\nu}$[14]. Combined with BaBar's bound[15], the HFAG average is given[1].

$$\mathrm{Br}(\tau^-\bar{\nu}) = \begin{cases} (88 \pm 68 \pm 11) \times 10^{-6} & \text{BaBar} \\ (176^{+56+46}_{-49-51}) \times 10^{-6} & \text{Belle} \\ (132 \pm 49) \times 10^{-6} & \text{HFAG Average} \end{cases}$$

In the SM, the branching ratio of $B^- \to \tau^-\bar{\nu}$ can be written as

$$\mathrm{BR}(B^- \to \tau^-\bar{\nu})_{\mathrm{SM}} = \frac{G_F^2 m_B m_\tau^2}{8\pi}\left(1 - \frac{m_\tau^2}{m_B^2}\right)^2 \times f_B^2 |V_{ub}|^2 \tau_B. \quad (11)$$

Thus with the theoretical input for B meson decay constant f_B, we can set the bound for $|V_{ub}|$. Figure 2 shows the impact of such bound on the $\bar{\rho} - \bar{\eta}$ plane. Combined with the results of $B_s - \bar{B}_s$ mixing, the constraints of $\bar{\rho} - \bar{\eta}$ plane is shown in Figure 3. Such constrained area is consistent with the global fitting (see Figure 3)[16].

If we consider the physics beyond the SM, the charged higgs can also contribute to $B^- \to \tau^-\bar{\nu}$.

$$\frac{\mathrm{BR}(B^- \to \tau^-\bar{\nu})}{\mathrm{BR}(B^- \to \tau^-\bar{\nu})_{\mathrm{SM}}} = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2. \quad (12)$$

This allows us to set the bound the on $\tan\beta/m_H$. Combining with the results from $B \to X_s\gamma$, the constraints on $\tan\beta - m_H$ is given in Figure 5[17].

NEW HADRONIC RESONANCES AT BABAR AND BELLE

At BaBar and Belle, many new hadronic resonances are observed. We list them below.

1) $D^*_{s,J}(2860)$:
BaBar measured $e^+e^- \to (DK)X$, and found DK resonance at mass $m_{DK} = 2856.6 \pm 1.5 \pm 5.0$ MeV$/c^2$ with

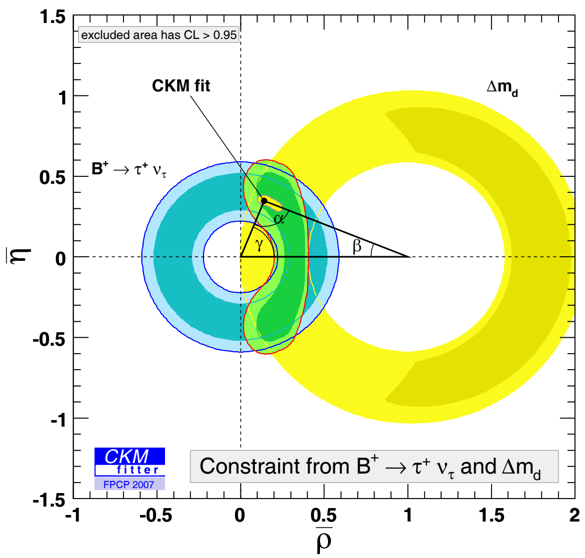

FIG. 2: Constraints for $\bar{\rho} - \bar{\eta}$ plane from $B^+ \to \tau^+ \nu$.

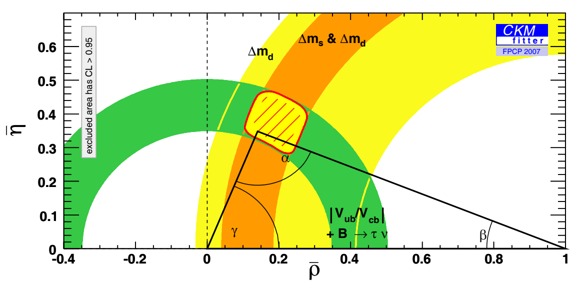

FIG. 3: Combined constraints for $\bar{\rho} - \bar{\eta}$ plane from $B^+ \to \tau^+ \nu$ and $B_s - \bar{B}_s$ mixing.

the decay width $\Gamma = 47 \pm 7 \pm 10$ MeV. This could be a radial excitation of $D^*_{s0}(2317)$.

2) $D_{sJ}(2700)$:
In the above analysis, BaBar also found another DK resonance $X(2690)$ at $m = (2688 \pm 4 \pm 3)$ MeV/c^2 with the decay width $\Gamma = (112 \pm 7 \pm 36)$MeV. Belle confirmed this state $D_{sJ}(2700)$ in $B^+ \to \bar{D}^0 D^0 K^+$ in which $D^0 K^+$ invariant mass peaks at $m = (2715 \pm 11^{+11}_{-14})$MeV/$c^2$ with

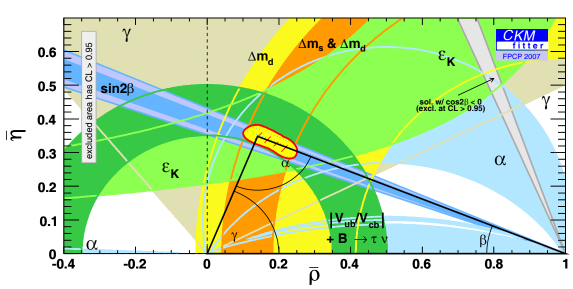

FIG. 4: Global fitting for $\bar{\rho} - \bar{\eta}$ plane.

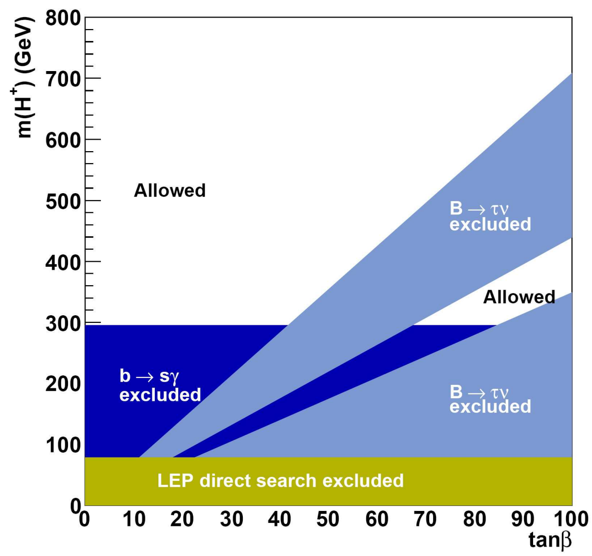

FIG. 5: The constraints of $\tan\beta - m_H$ from B decays.

the decay width $\Gamma = (115 \pm 20^{+36}_{-32})$MeV.

3) $X(3940)$, $Y(3940)$ and $Z(3930)$ ($c\bar{c}$ mesons):
Belle observed the $X(3940)$ resonance in

$$e^+e^- \to J/\Psi X(3940): \quad \begin{array}{l} m = (3943 \pm 6 \pm 6)\text{MeV}/c^2 \\ \Gamma = (15.4 \pm 10.1)\text{MeV} \end{array}$$

$X(3940)$ could be the radially excited charmonium $\eta_c(3s)[3\ ^1S_0]$.

Belle also found that in $B \to J/\Psi \omega K$, $J/\Psi \omega$ invariant mass peaks at

$$Y(3940): \quad \begin{array}{l} m = (3943 \pm 11 \pm 13)\text{MeV}/c^2 \\ \Gamma = (87 \pm 22 \pm 26)\text{MeV} \end{array}$$

$Y(3940)$ could be $\chi'_{c1}[2\ ^3P_1]$.

In $\gamma\gamma \to D\bar{D}$, $D\bar{D}$ invariant mass peaks at

$$Z(3930): \quad \begin{array}{l} m = (3929 \pm 5 \pm 2)\text{MeV}/c^2 \\ \Gamma = (29 \pm 10 \pm 2)\text{MeV} \end{array} \tag{13}$$

$Z(3930)$ could be $\chi'_{c2}[2\ ^3P_2]$.

4) $X(3872)$:
Belle found this resonance in

$$\begin{array}{rcl} B^\pm & \to & X(3872)K^\pm \\ & & \hookrightarrow J/\Psi\pi\pi \end{array}$$

$J/\Psi\pi\pi$ invariant mass peaks at $m = (3871.81 \pm 0.36)$MeV/c^2 with narrow decay width $\Gamma < 2.3$MeV.

5) $Y(4260)$:
BaBar observed this resonance in $e^+e^- \to \gamma_{\rm isr}(J/\Psi\pi^+\pi^-)$ (isr for initial state radiated). The $J/\Psi\pi\pi$ invariant mass peaks at

	B_1^0	B_2^{*0}
CDF	$5734 \pm 3 \pm 2$	$5738 \pm 5 \pm 1$
$D0$	$5720.8 \pm 2.5 \pm 5.3$	$5746 \pm 2.4 \pm 5.4$
	B_{s1}	B_{s2}^{*0}
CDF	$5829.4 \pm 0.2 \pm 0.6$	$5839.6 \pm 0.4 \pm 0.5$
$D0$		$5839.1 \pm 1.4 \pm 1.5$

TABLE IV: Exited B meson spectra.

$m = (4295 \pm 10^{+10}_{-\ 3})\mathrm{MeV}/c^2$ with the decay width $\Gamma = (88 \pm 23)$MeV. It is confirmed by Belle and CLEO.

$$\text{Belle}: \begin{array}{l} m = (4295 \pm 10^{+10}_{-\ 3})\mathrm{MeV}/c^2 \\ \Gamma = (133^{+26+13}_{-22-\ 6})\mathrm{MeV} \end{array}$$
$$\text{CLEO}: m = (4283^{+17}_{-16} \pm 4)\mathrm{MeV}/c^2$$

b-FLAVORED HADRON SPECTRUM

B factories are unable to produce the heavy b-flavored hadrons such as B_s, excited B mesons, and b-baryons. These hadronic states can only be accessible at the hadron colliders.

We collect the recent measurements from TEVATRON on the spectra of b-flavored baryons as the following[18]:

$$\begin{aligned} m(\Lambda_b) &= 5619.7 \pm 1.2 \quad \mathrm{MeV} \\ m(\Sigma_b^-) &= 5815.2^{+1.0}_{-1.9} \pm 1.7 \quad \mathrm{MeV} \\ m(\Sigma_b^+) &= 5807.5^{+1.9}_{-2.2} \pm 1.7 \quad \mathrm{MeV} \\ m(\Sigma_b^{*-}) &= 5836.7^{+2.0+1.8}_{-2.3-1.7} \quad \mathrm{MeV} \\ m(\Sigma_b^{*+}) &= 5829.0^{+1.6+1.7}_{-1.7-1.8} \quad \mathrm{MeV} \\ m(\Xi_b^-) &= (5774 \pm 11 \pm 15) \quad \mathrm{MeV} \end{aligned}$$

The status of the excited $L = 1$, $j^p = 3/2^+$ B mesons (B_J, B_{sJ}) masses (MeV) are listed in Table IV.

CONCLUSION

Almost 30 years after the discovery of b quark, and 7 years B factories running, B physics has entered a precision test era. The higher order theoretical calculations are essential to explain the more and more accurate experimental data, especially the data for non-leptonic decays. This does not only require the straight-forward but tough computation but also developing new theoretical concepts in heavy flavor physics.

For the theoretically clean decays, the new experimental measurements shed a light on the precision test of the SM and the door towards new physics.

B factories are also good places to find charmed mesons and charmonium states. The recently observed new mesons properties still need further theoretical study.

LHC will run in next year, B physics will enter a new era. We can fully explore all the b-flavored hadrons and their decays. Theorists will find more interesting subjects there.

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[1] Heavy Flavor Averaging Group, http://www.slac.stanford.edu/xorg/hfag/index.html.
[2] M. Beneke and M. Neubert, Nucl. Phys. B **675**, 333 (2003) [arXiv:hep-ph/0308039].
[3] T. Yoshikawa, Phys. Rev. D **68**, 054023 (2003) [arXiv:hep-ph/0306147].
[4] M. Beneke and S. Jager, Nucl. Phys. B **751**, 160 (2006) [arXiv:hep-ph/0512351].
[5] M. Beneke and S. Jager, Nucl. Phys. B **768**, 51 (2007) [arXiv:hep-ph/0610322].
[6] M. Beneke and D. Yang, Nucl. Phys. B **736**, 34 (2006) [arXiv:hep-ph/0508250].
[7] G. Bell, arXiv:0705.3127 [hep-ph].
[8] B. Aubert *et al.*, Phys. Rev. Lett. **91**, 171802 (2003); Phys. Rev. Lett. **93**, 231804 (2004); [hep-ex/0408093]; K. F. Chen *et al.*, Phys. Rev. Lett. **91**, 201801 (2003); Phys. Rev. Lett. **94**, 221804 (2005); J. Zhang *et al.*, [hep-ex/0505039].
[9] H. Y. Cheng and K. C. Yang, Phys. Lett. B **511**, 40 (2001) [arXiv:hep-ph/0104090]; X. Q. Li, G. r. Lu and Y. D. Yang, Phys. Rev. D **68**, 114015 (2003) [Erratum-ibid. D **71**, 019902 (2005)] [arXiv:hep-ph/0309136]; A. L. Kagan, Phys. Lett. B **601**, 151 (2004) [arXiv:hep-ph/0405134]; P. Colangelo, F. De Fazio and T. N. Pham, Phys. Lett. B **597**, 291 (2004) [arXiv:hep-ph/0406162]; W. S. Hou and M. Nagashima, arXiv:hep-ph/0408007; H. n. Li and S. Mishima, Phys. Rev. D **71**, 054025 (2005) [arXiv:hep-ph/0411146]; Y. D. Yang, R. M. Wang and G. R. Lu, Phys. Rev. D **72**, 015009 (2005) [arXiv:hep-ph/0411211]; P. K. Das and K. C. Yang, Phys. Rev. D **71**, 094002 (2005) [arXiv:hep-ph/0412313]; H. n. Li, Phys. Lett. B **622**, 63 (2005) [arXiv:hep-ph/0411305]; C. S. Kim and Y. D. Yang, arXiv:hep-ph/0412364; W. j. Zou and Z. j. Xiao, Phys. Rev. D **72**, 094026 (2005) [arXiv:hep-ph/0507122]; C. S. Huang, P. Ko, X. H. Wu and Y. D. Yang, Phys. Rev. D **73**, 034026 (2006) [arXiv:hep-ph/0511129]; Q. Chang, X. Q. Li and Y. D. Yang, JHEP **0706**, 038 (2007) [arXiv:hep-ph/0610280].
[10] H. W. Huang, C. D. Lu, T. Morii, Y. L. Shen, G. Song and Jin-Zhu, Phys. Rev. D **73**, 014011 (2006) [arXiv:hep-ph/0508080]; S. Baek, A. Datta, P. Hamel, O. F. Hernandez and D. London, Phys. Rev. D **72**, 094008 (2005) [arXiv:hep-ph/0508149].
[11] M. Beneke, J. Rohrer and D. Yang, Nucl. Phys. B **774**, 64 (2007) [arXiv:hep-ph/0612290].

[12] M. Beneke, J. Rohrer and D. Yang, Phys. Rev. Lett. **96**, 141801 (2006) [arXiv:hep-ph/0512258].

[13] A. Abulencia *et al.* [CDF - Run II Collaboration], Phys. Rev. Lett. **97**, 062003 (2006) [AIP Conf. Proc. **870**, 116 (2006)] [arXiv:hep-ex/0606027]; V. M. Abazov *et al.* [D0 Collaboration], Phys. Rev. Lett. **97**, 021802 (2006) [arXiv:hep-ex/0603029].

[14] K. Ikado *et al.*, Phys. Rev. Lett. **97**, 251802 (2006) [arXiv:hep-ex/0604018].

[15] G. Nardo *et al.* [BABAR Collaboration], arXiv:0708.2260 [hep-ex].

[16] CKMfitter Group, http://ckmfitter.in2p3.fr/.

[17] M. Nakao, talk given at LP2007, Korea.

[18] CDF colaborations, hep-ex/0702047; D0 colaborations, hep-ex/0706.1690.